BRITISH STANDARD

BS EN
933-4:2000

Tests for geometrical properties of aggregates —

Part 4: Determination of particle shape — Shape index

The European Standard EN 933-4:1999 has the status of a British Standard

ICS 91.100.15

National foreword

This British Standard is the English language version of EN 933-4:1999. It is included in a package of European Standards agreed by CEN/TC 154.

The UK participation in its preparation was entrusted by Technical Committee B/502, Aggregates, to Subcommittee B/502/6, Test methods, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 10, an inside back cover and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

This British Standard, having been prepared under the direction of the Sector Committee for Building and Civil Engineering, was published under the authority of the Standards Committee and comes into effect on 15 January 2000

ISBN 0 580 35276 5

Amendments issued since publication

Amd. No.	Date	Comments

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 933-4

October 1999

ICS 91.100.15; 91.100.20

English version

Tests for geometrical properties of aggregates – Part 4: Determination of particle shape – Shape index

Essais pour déterminer les caractéristiques géométriques des granulats – Partie 4: Détermination de la forme des grains – Indice de forme

Prüfverfahren für geometrische Eigenschaften von Gesteinskörnungen – Teil 4: Bestimmung der Kornform - Kornformkennzahl

This European Standard was approved by CEN on 3 September 1999.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Central Secretariat: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 993-4:1999 E

Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 154 "Aggregates", the Secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2000, and conflicting national standards shall be withdrawn at the latest by December 2003.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom

This European Standard is one of a series of standards for tests for geometrical properties of aggregates. Test methods for other properties of aggregates are covered by Parts of the following European Standards:

EN 932	Tests for general properties of aggregates
EN 1097	Tests for mechanical and physical properties of aggregates
EN 1367	Tests for thermal and weathering properties of aggregates
EN 1744	Tests for chemical properties of aggregates
PrEN 13179	Tests for filler aggregate used in bituminous mixtures

The other parts of EN 933 will be:

Part 1	Determination of particle size distribution - Sieving method
Part 2	Determination of particle size distribution - Test sieves, nominal size of apertures
Part 3	Determination of particle shape - Flakiness index
Part 5	Determination of percentage of crushed and broken surfaces in coarse aggregate particles
Part 6	Determination of particle shape - Flakiness index
Part 7	Determination of shell content - Percentage of shells for coarse aggregates
Part 8	Assessment of fines - Sand equivalent test
Part 9	Assessment of fines - Methylene blue test
Part 10	Assessment of fines - Grading of fillers (air jet sieving)

1 Scope

This European Standard specifies a method for the determination of the shape index of coarse aggregates. It applies to aggregates of natural or artificial origin, including lightweight aggregates.

The test method specified in this European Standard is applicable to particle size fractions d_i/D_i where $D_i \leq 63$ mm and $d_i \geq 4$ mm.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. The normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

EN 932-2	Test for general properties of aggregates - Part 2: Methods for reducing laboratory samples
PrEN 932-5	Tests for general properties of aggregates - Part 5: Common equipment and calibration
EN 933-1	Tests for geometrical properties of aggregates - Part 1: Determination of particle size distribution - Sieving method
EN 933-2	Tests for geometrical properties of aggregates - Part 2: Determination of particle size distribution - Test sieves, nominal size of apertures
prEN 1097-6	Tests for mechanical and physical properties of aggregates - Part 6: Determination of the particle density and water absorption

3 Definitions

For the purposes of this standard, the following definitions apply:

3.1 aggregate size: Designation of aggregate in terms of lower (*d*) and upper (*D*) sieve sizes, expressed as *d*/*D*.

NOTE: This designation accepts the presence of some particles which will be retained on the upper sieve (oversize) and some which will pass the lower sieve (undersize).

3.2 particle size fraction d_i/D_i: Fraction of an aggregate passing the larger (D_i) of two sieves and retained on the smaller (d_i).

3.3 test portion: Sample used as a whole in a single test.

3.4 constant mass: Successive weighings after drying at least 1 h apart not differing by more than 0,1%.

NOTE: In many cases constant mass can be achieved after a test portion has been dried for a pre-determined period in a specified oven (see **5.5**) at (110 ± 5) °C. Test laboratories can determine the time required to achieve constant mass for specific types and sizes of sample dependent upon the drying capacity of the oven used.

3.5 particle length *L*: Maximum dimension of a particle as defined by the greatest distance apart of two parallel planes tangential to the particle surface.

3.6 particle thickness *E*: Minimum dimension of a particle as defined by the least distance apart of two parallel planes tangential to the particle surface.

4 Principle

Individual particles in a sample of coarse aggregate are classified on the basis of the ratio of their length *L* to thickness *E* using a particle slide gauge where necessary.

The shape index is calculated as the mass of particles with a ratio of dimensions *L/E* more than 3 expressed as a percentage of the total dry mass of particles tested.

5 Apparatus

5.1 All apparatus, unless otherwise stated, shall conform to the general requirements of prEN 932-5.

5.2 Particle slide gauge, an example of which is shown in figure 1.

5.3 Test sieves, with nominal size of apertures as specified in EN 933-2.

5.4 Tightly fitting pan and lid, for the sieves.

5.5 Ventilated oven, thermostatically controlled to maintain a temperature of (110 ± 5) °C, or other suitable equipment for drying the aggregates, if it does not cause any particle size breakdown.

5.6 Balances or scales, of suitable capacity, readable to 0,1% of the mass to be weighed.

5 7 Trays.

5.8 Sieving machine, (optional).

Dimensions in millimetres

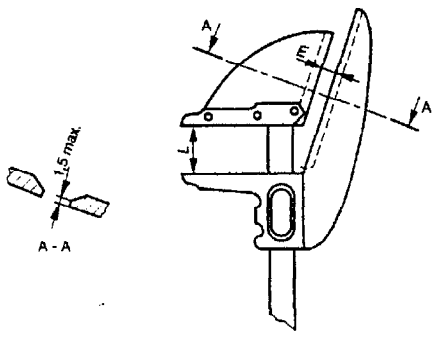

Figure 1: Example of a particle slide gauge

6 Preparation of test portion

The sample shall be reduced in accordance with the requirements of EN 932-2.

Dry the sample at (110 ± 5) °C to constant mass.

Sieve on appropriate test sieves with sufficient vigour to ensure complete separation of particles greater than 4 mm. Discard the particles retained on the 63 mm test sieve and those passing the 4 mm test sieve.

If necessary further reduce the sample in accordance with EN 932-2 to produce a test portion. Record the mass of the test portion as M_o.

The mass of the test portion shall be as specified in table 1.

Table 1: Mass of test portions

Upper aggregate size D mm	Test portion mass (minimum) kg
63	45
32	6
16	1
8	0,1
NOTE 1: For the other upper aggregate sizes D, appropriate test portion masses may be interpolated from those given in table 1. NOTE 2: For aggregates of particle density less than 2,00 Mg/m^3 or more than 3,00 Mg/m^3 in accordance with prEN 1097-6 an appropriate correction should be applied to the test portion masses given in table 1 based on the density ratio, in order to produce a test portion of approximately the same volume as those for aggregates of normal density.	

Sample reduction shall yield a test portion of mass larger than the minimum but not of an exact predetermined value.

7 Procedure

7.1 General

The test shall be carried out on each particle size fraction d_i/D_i where $D_i \leq 2d_i$.

Test portions from samples for which $D > 2d$ shall be separated into particle size fractions d_i/D_i where $D_i \leq 2d_i$ during the subsequent test procedure.

7.2 Test portions where $D \leq 2d$

Separate the predominant particle size fraction d_i/D_i where $D_i \leq 2d_i$ from the test portion by sieving in accordance with EN 933-1.

NOTE 1: Test sieves of appropriate aperture sizes from the following series should be used, viz. 4 mm; 5,6 mm; 8 mm; 11,2 mm; 16 mm; 22,4 mm; 31,5 mm; 45 mm; 63 mm; and the values of d_i and D_i of the size fraction tested should be recorded in the test report.

Discard any particles smaller than d_i or larger than D_i.

Record the mass of the predominant particle size fraction d_i/D_i as M_1.

Assess the length L and thickness E of each particle using a particle slide gauge where necessary and set aside those particles which have a dimensional ratio $L/E > 3$. These particles are classified as non-cubical.

NOTE 2: The number of particles requiring individual classification using the gauge can be reduced by a preliminary separation of particles with L/E ratio significantly different from 3.

Weigh the non-cubical particles and record their mass as M_2.

7.3 Test portion where $D > 2d$

Separate the test portion into particle size fractions d_i/D_i where $D_i \leq 2d_i$ by sieving in accordance with EN 933-1.

NOTE 1: Test sieves of appropriate aperture sizes from the following series should be used, viz. 4 mm; 5,6 mm; 8 mm; 11,2 mm; 16 mm; 22,4 mm; 31,5 mm; 45 mm; 63 mm; and the values of d_i and D_i of each size fraction tested should be recorded in the test report.

Record the mass of each particle size fraction (M_i) and calculate and record the percentage by mass of each particle size fraction d_i/D_i to the test portion mass M_0 as V_i.

Discard any size fraction d_i/D_i which comprises less than 10% of M_0.

NOTE 2: If any remaining size fraction d_i/D_i contains less than 100 particles, it should if required, be recorded in the test report.

Any size fraction d_i/D_i which contains an excessive number of particles can be further reduced in accordance with EN 932-2, but after such reduction at least 100 particles of that size fraction shall remain.

Record the mass of particles to be tested in each remaing particle size fraction d_i/D_i as M_{1i}.

Assess the length L and thickness E of each particle using a particle slide gauge where necessary and set aside those particles in each size fraction which have a dimensional ratio $L/E > 3$. These particles are classified as non-cubical.

Record the mass of non-cubical particles in each of these size fractions d_i/D_i as M_{2i}.

8 Calculation and expression of results

8.1 Test portions where $D \leq 2d$

Calculate the shape index (*SI*) in accordance with the following equation:

$$SI = (M_2 / M_1) \times 100$$

where:

M_1 is the mass of the test portion, in grams;
M_2 is the mass of the non-cubical particles, in grams.

Record the shape index to the nearest whole number.

8.2 Test portions where $D > 2d$

8.2.1 Size fractions not reduced

Calculate the shape index (*SI*) in accordance with the following equation:

$$SI = \frac{\Sigma M_{2i}}{\Sigma M_{1i}} \times 100$$

where:

ΣM_{1i} is the sum of the masses of the size fractions tested, in grams;
ΣM_{2i} is the sum of the masses of the non-cubical particles in each of the size fractions tested, in grams.

Record the shape index to the nearest whole number.

8.2.2 Reduced size fractions

Calculate the percentage of non-cubical particles in each size fraction tested and record as SI_i. Calculate the weighted mean percentage of non-cubical particles (*SI*) in accordance with the following equation:

$$SI = \frac{\Sigma(V_i \times SI_i)}{\Sigma V_i}$$

where:

V_i is the percentage by mass of particle size fraction i in the sample tested;
SI_i is the percentage by mass of non-cubical particles in particle size fraction i.

Record the weighted mean percentage of non-cubical particles to the nearest whole number.

9 Test report

9.1 Required data

The test report shall include the following information:

a) reference to this European Standard;
b) identification of the laboratory;
c) identification of the sample;
d) shape index (*SI*) to the nearest whole number;
e) values of d_i and D_i of particle size fractions tested;
f) sample reception date.

9.2 Optional data

The test report can include the following information:

a) name and location of the sample source;
b) description of material and of sample reduction procedure;
c) mass of test portion (M_0);
d) mass of size fraction(s) tested (M_1 or M_{1i});
e) mass of non-cubical particles in size fraction(s) tested(M_2 or M_{2i});
f) any size fraction d/D_i with less than 100 particles;
g) sampling certificate, if available;
h) date of test.

Annex A (informative)

Example of a test data sheet used for determining the shape index of coarse aggregate

EN 933-4	Laboratory :
Identification of the sample:	Date :
	Operator :

M_o = g

Particle size fraction d_i/D_i where $D_i \leq 2d_i$ mm	Mass M_1 g	Mass M_2 g	Shape index SI % = $(M_2/M_1) \times 100$ to the nearest whole number

NOTE: When a particle size fraction d_i/D_i has been reduced an appropriate test data sheet can be used and the weighted mean values calculated as specified in **8.2**.

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL